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FORM PTO-1390 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE
(REV. 11-2000)

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER	
32860-000203/US	
U.S. APPLICATION NO. (If known, see 37 CFR 1.5)	
09/980173	
INTERNATIONAL APPLICATION NO.	**INTERNATIONAL FILING DATE**
PCT/DE00/01503	May 12, 2000
PRIORITY DATE CLAIMED	
May 28, 1999	

TITLE OF INVENTION
INSPECTION DEVICE FOR AN ANNULAR COMBUSTION CHAMBER OF A GAS TURBINE AND METHOD OF INSPECTING AN ANNULAR COMBUSTION CHAMBER OF A GAS TURBINE

APPLICANT(S) FOR DO/EO/US
Ulrich ADAMS

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39 (1).
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau). WO 00/73762 A1
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is transmitted herewith.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4)
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 20. below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98-1449 and International Search Report (PCT/ISA/210) in German with ( ) references.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☒ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information:
    1) Two (2) sheets of Formal Drawings

U.S. APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
09/980173 NEW	PCT/DE00/01503	32860-000203/US

21. ☒ The following fees are submitted:

	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO. **$1,040.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO. **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$690.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4). **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	**$ 890.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	**$ 130.00**	

☐ CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	7 - 20 =	0	X **$18.00**	**$ 0**	
Independent Claims	3 - 3 =	0	X **$80.00**	**$ 0**	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)		None	+ **$270.00**	**$ 0**	
			TOTAL OF ABOVE CALCULATIONS =	**$ 1,020.00**	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				**$ 0**	
			SUBTOTAL =	**$ 1,020.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐20 ☐30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				**$ 0**	
			TOTAL NATIONAL FEE =	**$ 1,020.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				**$**	
			TOTAL FEES ENCLOSED =	**$ 1,020.00**	
				Amount to be: refunded	**$**
				charged	**$**

a. ☐ A check in the amount of $ _____ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account. No. 08-0750 in the amount of $1,020.00 to cover the above fees. A triplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 08-0750.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

Send all correspondence to:
Harness, Dickey & Pierce, P.L.C – Customer No. 30596
Post Office Box 8910
Reston, Virginia 20195

Date: November 28, 2001

By _____
Donald J. Daley, #34,313

/kna

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Express Mail No.: ET756564007US

Date of Deposit: November 28, 2001

Applicants:	Ulrich ADAMS
Int'l Application No.:	PCT/DE00/01503
Application No.:	**NEW**
Filed:	November 28, 2001
For:	INSPECTION DEVICE FOR AN ANNULAR COMBUSTION CHAMBER OF A GAS TURBINE AND METHOD OF INSPECTING AN ANNULAR COMBUSTION CHAMBER OF A GAS TURBINE
Docket No.:	32860-000203/US

Box PCT
Hon. Commissioner of Patents and Trademarks
Washington, D.C. 20231

EXPRESS MAIL TRANSMITTAL

The following papers are being deposited with the United States Postal Service Express Mail Post Office To Addressee and addressed for receipt by the United States Patent and Trademark Office:

PCT Transmittal Letter (3 copies)
Preliminary Amendment
Marked-Up Version of Specification
Substitute Specification (6 pages)
Copy of International Application as filed
English Language Original Specification (12 pages)
Two (2) sheets of Formal Drawings

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Donald J. Daley, Reg. No. 34,313

PATENT
32860-000203

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicants: Ulrich ADAMS

Int'l Application: PCT/DE00/01503

Application No.: **NEW**

Filed: November 28, 2001

For: INSPECTION DEVICE FOR AN ANNULAR COMBUSTION CHAMBER OF A GAS TURBINE AND METHOD OF INSPECTING AN ANNULAR COMBUSTION CHAMBER OF A GAS TURBINE

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, DC 20231

November 28, 2001

Sir:

The following preliminary amendments and remarks are respectfully submitted in connection with the above-identified application.

IN THE ABSTRACT

Please replace the Abstract with the attached revised Abstract.

IN THE CLAIMS

Please replace the original claims with the following new claims:

1. (Amended) A remote-controlled inspection device for an annular combustion chamber of a gas turbine, comprising:

a remotely steerable drive mechanism;

a moveable video camera;

a lighting arrangement;

a carrying framework for the video camera, for the drive mechanism and for the lighting arrangement; and

means for transmitting video images from the video camera to an evaluation arrangement.

2. (Amended) The inspection device as claimed in claim 1, wherein the drive mechanism includes an electric motor and wheels, at least one of said wheels being drivable by the electric motor.

3. (Amended) The inspection device as claimed in claim 1, wherein the drive mechanism includes a C-shaped rail, by way of which the carrying framework is capable of traveling.

4. (Amended) The inspection device as claimed in claim 1, wherein the drive mechanism includes an articulated arm, on which the carrying framework is mounted.

5. (Amended) A method for inspecting an annular combustion chamber of a gas turbine, comprising:

introducing a video camera, by remote steering, into the annular combustion chamber;

pivoting the video camera in such a way that video images of regions of internal walls of the annular combustion chamber are recorded by the video camera; and

transmitting video images to an evaluation arrangement positioned outside the annular combustion chamber.

Please add the following new claims:

-- 6. The inspection device as claimed in claim 2, wherein the drive mechanism includes a C-shaped rail, by way of which the carrying framework is capable of traveling.

7. An apparatus for inspecting an annular combustion chamber of a gas turbine, comprising:

means for introducing a video camera, by remote steering, into the annular combustion chamber;

means for pivoting the video camera in such a way that video images of regions of internal walls of the annular combustion chamber are recorded by the video camera; and

means for transmitting video images to an evaluation arrangement positioned outside the annular combustion chamber. --

REMARKS

Claims 1-7 are now present in this application, with new claims 6 and 7 being added by the present Preliminary Amendment. It should be noted that the amendments to original claims 1-7 of the present application are non-narrowing amendments, made solely to place the claims in proper form for U.S. practice and not to overcome any prior art or for any other statutory considerations. For example, amendments have been made to broaden the claims; remove reference numerals in the claims; remove multiple dependencies in the claims; and to place claims in a more recognizable U.S. form, including the use of the transitional phrase "comprising". Other such non-narrowing amendments include reorganizing apparatus-type

claims and method claims (setting elements forth in separate paragraphs) in a more recognizable U.S. form. Again, all amendments are non-narrowing and have been made solely to place the claims in proper form for U.S. practice and not to overcome any prior art or for any other statutory considerations.

SUBSTITUTE SPECIFICATION

In accordance with 37 C.F.R. §1.125, a substitute specification has been included in lieu of substitute paragraphs in connection with the present Preliminary Amendment. The substitute specification is submitted in clean form, attached hereto, and is accompanied by a marked-up version showing the changes made to the original specification. The changes have been made in an effort to place the specification in better form for U.S. practice. No new matter has been added by these changes to the specification. Further, the substitute specification includes paragraph numbers to facilitate amendment practice as requested by the U.S. Patent and Trademark Office.

CONCLUSION

Accordingly, in view of the above amendments and remarks, an early indication of the allowability of each of claims 1-7 in connection with the present application is earnestly solicited.

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Donald J. Daley at the telephone number of the undersigned below.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 08-0750 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

HARNESS, DICKEY & PIERCE, P.L.C

By: ______________________
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DJD:kna

ABSTRACT OF THE DISCLOSURE

A remote-controlled inspection device is for an annular combustion chamber of a gas turbine. Inspection takes place by using a video camera. Inspection by using the inspection device achieves a considerable reduction in the inspection time and an accurate documentation of the wear of the annular combustion chamber.

GR 99 P 3371

Description

Inspection device for an annular combustion chamber of a gas turbine and method for inspecting an annular combustion chamber of a gas turbine

The invention relates to a remote-controlled inspection device for an annular combustion chamber of a gas turbine. The invention relates, furthermore, to a method for inspecting an annular combustion chamber of a gas turbine.

US patent specification 4,255,762 discloses a device for inspecting tubes. An optical system for recording test images of the inner surface of the tubes is mounted on a test head of the device. The test device has a positioning mechanism, by means of which the test head can be moved in translational and rotational motion. Video images in a tube surface can be presented outside the tube by means of an evaluation arrangement. The test head is guided contactlessly in the tube by means of a clearance sensor.

DE 41 32 281 A1 shows a drive assembly for travel through a pipeline. The drive assembly has a drive, a plurality of sun wheels driven in rotation by the drive, in each case at least two planet wheels meshing with each sun wheel and a plurality of driving wheels with running surfaces. The running surfaces are pressed against the inner wall surface of the tube as a result of the orbital rotation of the planet wheels. A travel probe, which is operated as an inspection unit for travel through a pipeline network with bends and branches, consists of the coupling of two of the drive assemblies described above. The drive assemblies are mounted at the front and rear ends of a bendable device. Jolt-free travel through a pipeline network thereby becomes possible.

The object of the invention is to specify how inspection of an annular combustion chamber of a gas turbine can be carried out quickly, cost-effectively and, in terms of reliable fault detection, in a particularly effective way.

To achieve this object, according to the invention, a remote-controlled inspection device for an annular combustion chamber of a gas turbine is specified, which has a remotely steerable drive mechanism, a moveable video camera, a lighting arrangement, a carrying framework for the video camera, the drive mechanism and the lighting arrangement, and means for transmitting video images from the video camera to an evaluation arrangement.

A combustion chamber of a gas turbine is a region subjected to very high thermal load. Such a combustion chamber has a heat-resistant inner lining. This inner lining is exposed to considerable oxidation and corrosion. This leads to wear which must be detected at an early stage before consequential damage induced by the wear occurs. Precisely in the case of inner linings designed for extreme thermal loads, often complex coating systems are applied to the inner lining in order to protect this. A local flaking of this coating must be detected at an early stage and reliably. Gas turbine burners which are likewise exposed to an extremely high thermal load issue into the combustion chamber. Particularly the swirl grids of such a burner which serve for generating a backflow stabilizing combustion must be checked regularly for wear. Finally, a first gas turbine guide-vane row following the combustion chamber is also exposed to extremely high thermal loads. Here, too, a regular and accurate check of the surface of the guide vanes is necessary.

The combustion chamber of a gas turbine has hitherto been tested by a direct visual inspection of the state

of the combustion chamber. In this case, either the gas turbine combustion chamber was opened at considerable outlay, to an extent such that access to all the regions to be tested was possible, or, where a very large stationary gas turbine was concerned, at least a part region of the combustion chamber was tested via manhole access. The assessment of an actual state of wear and, in particular, the detection of possibly critical regions requiring maintenance make it necessary to have highly experienced personnel. On account of this very critical test and because of the basic accessibility of a gas turbine combustion chamber by direct visual inspection, it has hitherto not been considered, or at any rate held to be technically feasible, to conduct a check by means of a remote-controlled optical detection system. Moreover, precisely where an annular combustion chamber is concerned, there is a complex inner geometry which, for a remote-controlled system, is accessible only with difficulty to an extent such that even all the regions to be tested can in actual fact be checked reliably.

The invention overcomes this prejudice. The invention, in this case, is based on the knowledge that, by means of such a remote-controlled inspection device with a video camera system, considerable additional advantages can be achieved, as compared with direct visual inspection, which have hitherto not be considered at all. On the one hand, by means of the remote-controlled inspection device, the complete annular combustion chamber can be inspected by manhole access, without the annular combustion chamber in this case being opened further. This results in considerable reductions in inspection times. Moreover, with the aid of the video system, the state of the combustion chamber can be documented accurately. Thus, for example, a comparison with earlier inspections and therefore, for example, a check of the rate of progress of wear are possible and even quantifiable. Furthermore, with the aid of video

detection, it becomes possible to assess the state of the combustion chamber independently of the location of the gas turbine. Thus, for example, inspection could take place according to an automated sequence and then the assessment of the state of wear of individual regions could be monitored, for example, centrally in a know-how center. Consequently, any existing problem areas in gas turbines of the same type can also be identified comprehensively in terms of machinery. Furthermore, the remote-controlled inspection device makes it possible, if necessary, by means of a position check to have an accurate assignment of positions of fault areas. Consequently, for example, fault elimination can take place specifically, during later maintenance, on the basis of the inspection data.

The drive mechanism preferably has an electric motor and wheels, at least one of said wheels being capable of being driven by the electric motor. The inspection device is thus designed as a vehicle which moves independently on wheels through the annular combustion chamber.

The drive mechanism preferably has an, in particular, C-shaped rail, by means of which the carrying framework is capable of traveling. In this embodiment, therefore, the video camera mounted on the carrying framework and having the lighting arrangement is introduced into the combustion chamber via a C-shaped rail. This rail may, for example, be extendable telescopically. By this rail being introduced into the annular combustion chamber via a manhole, it is thus possible to inspect the annular combustion chamber by means of a video camera mounted on the rail.

The drive mechanism preferably has an articulated arm, on which the carrying framework is mounted. This embodiment corresponds, in terms of the way it functions, to the rail inasmuch as the video camera and

the lighting system are introduced via a suitable point, for example the manhole, into the annular combustion chamber and are guided from there through the annular combustion chamber by remote steering. In this case, too, no further uncovering of the annular combustion chamber is necessary.

The object is also achieved, according to the invention, by means of a method for inspecting an annular combustion chamber of a gas turbine, in which a video camera is introduced, by remote steering, into the annular combustion chamber and is pivoted in such a way that video images of regions of the internal walls of the annular combustion chamber are recorded by the video camera, said video images being transmitted to an evaluation arrangement positioned outside the annular combustion chamber. The advantages of such a method correspond to the statements made above with regard to the advantages of the inspection device.

The exemplary embodiments of the invention are explained in more detail by means of the drawing in which, partially diagrammatically and not true to scale,

fig. 1 shows a longitudinal section through a gas turbine,

fig. 2 shows an inspection device designed as a vehicle,

fig. 3 shows an inspection device arranged on telescopic rail, and

fig. 4 shows an inspection device with an articulated arm.

Identical reference symbols have the same significance in the figures.

Fig. 1 shows a gas turbine 1. A compressor 3, an annular combustion chamber 5 and a turbine part 7 are

disposed in succession and so as to be connected to one another. The annular combustion chamber 5 forms, by virtue of an inner internal wall 9 and an outer internal wall 11, a ring-shaped annular space 10 narrowing in the direction of the turbine part 7. At the compressor-side end of the annular combustion chamber 5, a gas turbine burner 13 issues into the annular combustion chamber 5. A first guide-vane row 15 of the turbine part 7 is disposed at that end of the annular combustion chamber 5 located on the turbine-part side.

Ambient air 17 is compressed by the compressor 3 and fed to the gas turbine burner 13. Fuel is admixed with the compressor air 17 in the gas turbine burner 13 and is ignited in the annular combustion chamber 5. The hot exhaust gas 19 thus occurring is delivered to the turbine part 7. The temperatures of more than 1000°C occurring at the same time subject all the components of the annular combustion chamber 5 to extremely high load. The annular combustion chamber 5 is therefore provided with an inner lining, not illustrated in any more detail here, which absorbs the thermal load caused by the hot exhaust gas 19. This inner lining consists, for example, of combustion chamber bricks which may be provided, in addition, with a corrosion and oxidation protective layer and with a ceramic heat-insulating layer. The first guide-vane row 15 and the mouth region of the gas turbine burner 13 are also subjected to extremely high thermal load. The high thermal load leads to oxidation and corrosion and may also result, for example, in material being stripped off, cracks, deformations, carbonization or flaking. Erosion due to foreign bodies entrained in the exhaust gas is likewise possible. The annular combustion chamber 5 must therefore be monitored regularly for such wear phenomena. For this purpose, a remote-controlled inspection device 21 is introduced into the annular combustion chamber 5. The inspection device 21 has a

carrying framework 24. The carrying framework 24 is formed by a lower frame 23 and an upper frame 25. Four wheels 29 are mounted in each case both on the lower frame 23 and on the upper frame 25. A translational rail 31 is mounted on the end face of the inspection device 21. A video camera 33, together with a lighting arrangement 35, is mounted on said translational rail so as to be moveable in translational motion from a burner-side end to a turbine-side end of the annular combustion chamber. The video camera 33 and the lighting arrangement 35 are held pivotably in an articulated fork 37. The articulated fork 37 is held rotatably on a shank 39. The combination of the translational motion on the translational rail 31 with the rotational motion of the shank 39 and the pivoting motion in the articulated fork 37 allows a complete inspection of the internal walls 9, 11 of the mouth region of the gas turbine burner 13 and of the first guide-vane row 15. A control and supply arrangement 41 disposed on the shank 39 serves for driving the movement for the video camera 33 and the electrical supply of the video camera 33 or the lighting system 35. Furthermore, preamplification of the video signal may take place in the control and supply unit 41. The video signal is conducted out of the annular combustion chamber 5 via a line 43. The power supply for the control and supply arrangement 41 also takes place via the line 43.

By means of the remote-controlled inspection device 21, a complete inspection of the annular combustion chamber 5, without a complicated covering or uncovering of said annular combustion chamber, may be carried out. This results in a considerable reduction in inspection time. Furthermore, storable documentation capable of being understood, irrespective of location, is made possible by the video detection of the state of the combustion chamber. Specialized personnel can thus assess the state of the annular combustion chamber 5 irrespective

of the location of the gas turbine 1. Moreover, progress of wear and quantification of the rate of progress of wear are possible by comparison with previous inspections. The remote-controlled inspection device 21 thus provides, as it were, a three-dimensional and time-related mapping of the state of the annular combustion chamber. As compared with a hitherto conventional inspection by direct visual inspection, therefore, there are entirely new possibilities for quantifying the thermally induced wear in the annular combustion chamber 5.

Fig. 2 shows a top view of an inspection device 21. The inspection device 21 has an electric motor 45. The electric motor 45 drives two of the wheels 29 via a shaft 47. A power supply of the electric motor 45 takes place via a supply line 49. The transmission of video images takes place via the line 43, as in fig. 1, the line 43 being connected to an evaluation arrangement 51. The evaluation arrangement 51 has a monitor 53 on which the video images can be displayed directly. The evaluation arrangement 51 also has a storage unit 55, via which the video images can be stored. Furthermore, video images of previous inspections can be retrieved by means of the storage arrangement 55. At the same time, a location-synchronized parallel display of current inspection images with previous inspection images can be carried out, so that a change in the state of wear becomes immediately visible. A power supply arrangement 57 serves for the power supply of the electric motor 45.

Fig. 3 shows a further embodiment of the remote-controlled inspection device 21. The video camera 33 and the lighting system 35 are introduced into the annular combustion chamber 5 via a telescopically extendable rail 61. A manhole 63 serves as access in this case. The rail 61 is C-shaped and can travel around half the circumference of the annular combustion

chamber 5. The carrying framework 24 for the video camera 33 and the lighting system 35 is either moved through the annular combustion chamber 5 by means of the rail 61 or the carrying framework 24 is mounted so as to be capable of traveling on the rail 61.

Fig. 4 shows a further embodiment of the inspection device 21. In this case, the carrying framework 24 for the video camera 33 and the lighting system 35 is moved through the annular combustion chamber by means of an articulated arm 71.

New PCT National Stage Application
Docket No. 32860-000203/US

SUBSTITUTE SPECIFICATION

INSPECTION DEVICE FOR AN ANNULAR COMBUSTION CHAMBER OF A GAS TURBINE AND METHOD OF INSPECTING AN ANNULAR COMBUSTION CHAMBER OF A GAS TURBINE

[0001] This application is the national phase under 35 U.S.C. § 371 of PCT International Application No. PCT/DE00/01503 which has an International filing date of May 12, 2000, which designated the United States of America, the entire contents of which are hereby incorporated by reference.

Field of the Invention

[0002] The invention generally relates to a remote-controlled inspection device for an annular combustion chamber of a gas turbine. Preferably, it relates to a method for inspecting an annular combustion chamber of a gas turbine.

Background of the Invention

[0003] US patent specification 4,255,762 discloses a device for inspecting tubes. An optical system for recording test images of the inner surface of the tubes is mounted on a test head of the device. The test device has a positioning mechanism, by which the test head can be moved in translational and rotational motion. Video images in a tube surface can be presented outside the tube by way of an evaluation arrangement. The test head is guided contactlessly in the tube by way of a clearance sensor.

[0004] DE 41 32 281 A1 shows a drive assembly for travel through a pipeline. The drive assembly has a drive, a plurality of sun wheels driven in rotation by the drive, in each case at least two planet wheels meshing with each sun wheel and a plurality of driving wheels with running surfaces. The running surfaces are pressed against the inner wall surface of the tube as a result of the orbital rotation of the planet wheels. A travel probe, which is operated as an inspection unit for travel through a pipeline network with bends and branches, includes the coupling of two of the drive assemblies described above. The drive assemblies are mounted at the front and rear ends of a bendable device. Jolt-free travel through a pipeline network thereby becomes possible.

SUMMARY OF THE INVENTION

[0005] An object of the invention is, for example, to specify how inspection of an annular combustion chamber of a gas turbine can be carried out quickly, cost-effectively and, in terms of reliable fault detection, in a particularly effective way.

[0006] To achieve this object, according to one aspect of the invention, a remote-controlled inspection device for an annular combustion chamber of a gas turbine is specified. Preferably, it has a remotely steerable drive mechanism, a moveable video camera, a lighting arrangement, a carrying framework for the video camera, the drive mechanism and the lighting arrangement, and device for transmitting video images from the video camera to an evaluation arrangement.

[0007] A combustion chamber of a gas turbine is a region subjected to very high thermal load. Such a combustion chamber has a heat-resistant inner lining. This inner lining is exposed to considerable oxidation and corrosion. This leads to wear which must be detected at an early stage before consequential damage induced by the wear occurs. Precisely in the case of inner linings designed for extreme thermal loads, often complex coating systems are applied to the inner lining in order to protect this. A local flaking of this coating should be detected at an early stage and reliably. Gas turbine burners which are likewise exposed to an extremely high thermal load issue into the combustion chamber. Particularly the swirl grids of such a burner which serve for generating a backflow stabilizing combustion must be checked regularly for wear. Finally, a first gas turbine guide-vane row following the combustion chamber is also exposed to extremely high thermal loads. Here, too, a regular and accurate check of the surface of the guide vanes is necessary.

[0008] The combustion chamber of a gas turbine has hitherto been tested by a direct visual inspection of the state of the combustion chamber. In this case, either the gas turbine combustion chamber was opened at considerable outlay, to an extent such that access to all the regions to be tested was possible, or, where a very large stationary gas turbine was concerned, at least a part region of the combustion chamber was tested via manhole access. The assessment of an actual state of wear and, in particular, the detection of possibly critical regions requiring maintenance make it necessary to have highly experienced personnel. On account of this very critical test and because of the basic accessibility of a gas turbine combustion chamber by direct visual inspection, it has hitherto not been considered, or at any rate held to be technically feasible, to conduct a check by using a remote-controlled optical detection system. Moreover, precisely where an annular combustion chamber is concerned, there is a complex inner geometry which, for a remote-controlled system, is accessible only with difficulty to an extent such that even all the regions to be tested can in actual fact be checked reliably.

[0009] The invention overcomes this prejudice. The invention, in this case, is based on the knowledge that, by use of such a remote-controlled inspection device with a video camera system, considerable additional advantages can be achieved, as compared with direct visual inspection, which have hitherto not be considered at all. On the one hand, by using the

remote-controlled inspection device, the complete annular combustion chamber can be inspected by manhole access, without the annular combustion chamber in this case being opened further. This results in considerable reductions in inspection times. Moreover, with the aid of the video system, the state of the combustion chamber can be documented accurately. Thus, for example, a comparison with earlier inspections and therefore, for example, a check of the rate of progress of wear are possible and even quantifiable. Furthermore, with the aid of video detection, it becomes possible to assess the state of the combustion chamber independently of the location of the gas turbine. Thus, for example, inspection could take place according to an automated sequence and then the assessment of the state of wear of individual regions could be monitored, for example, centrally in a know-how center. Consequently, any existing problem areas in gas turbines of the same type can also be identified comprehensively in terms of machinery. Furthermore, the remote-controlled inspection device makes it possible, if necessary, by using a position check to have an accurate assignment of positions of fault areas. Consequently, for example, fault elimination can take place specifically, during later maintenance, on the basis of the inspection data.

[00010] The drive mechanism preferably has an electric motor and wheels, at least one of said wheels being capable of being driven by the electric motor. The inspection device is thus designed as a vehicle which moves independently on wheels through the annular combustion chamber.

[00011] The drive mechanism preferably has an, in particular, C-shaped rail, by way of which the carrying framework is capable of traveling. In this embodiment, therefore, the video camera mounted on the carrying framework and having the lighting arrangement is introduced into the combustion chamber via a C-shaped rail. This rail may, for example, be extendable telescopically. By this rail being introduced into the annular combustion chamber via a manhole, it is thus possible to inspect the annular combustion chamber by using a video camera mounted on the rail.

[00012] The drive mechanism preferably has an articulated arm, on which the carrying framework is mounted. This embodiment corresponds, in terms of the way it functions, to the rail inasmuch as the video camera and the lighting system are introduced via a suitable point, for example the manhole, into the annular combustion chamber and are guided from there through the annular combustion chamber by remote steering. In this case, too, no further uncovering of the annular combustion chamber is necessary.

[00013] An object is also achieved, according to the invention, by a method for inspecting an annular combustion chamber of a gas turbine, in which a video camera is introduced, by remote steering, into the annular combustion chamber and is pivoted in such a way that video images of regions of the internal walls of the annular combustion chamber are recorded by

the video camera, the video images being transmitted to an evaluation arrangement positioned outside the annular combustion chamber. The advantages of such a method correspond to the statements made above with regard to the advantages of the inspection device.

BRIEF DESCRIPTION OF THE DRAWINGS

[00014] The exemplary embodiments of the invention are explained in more detail by way of the drawing in which, partially diagrammatically and not true to scale,

Fig. 1 shows a longitudinal section through a gas turbine,

Fig. 2 shows an inspection device designed as a vehicle,

Fig. 3 shows an inspection device arranged on telescopic rail, and

Fig. 4 shows an inspection device with an articulated arm.

[00015] Identical reference symbols have the same significance in the figures.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[00016] Fig. 1 shows a gas turbine 1. A compressor 3, an annular combustion chamber 5 and a turbine part 7 are disposed in succession and so as to be connected to one another. The annular combustion chamber 5 forms, by virtue of an inner internal wall 9 and an outer internal wall 11, a ring-shaped annular space 10 narrowing in the direction of the turbine part 7. At the compressor-side end of the annular combustion chamber 5, a gas turbine burner 13 issues into the annular combustion chamber 5. A first guide-vane row 15 of the turbine part 7 is disposed at that end of the annular combustion chamber 5 located on the turbine-part side.

[00017] Ambient air 17 is compressed by the compressor 3 and fed to the gas turbine burner 13. Fuel is admixed with the compressor air 17 in the gas turbine burner 13 and is ignited in the annular combustion chamber 5. The hot exhaust gas 19 thus occurring is delivered to the turbine part 7. The temperatures of more than 1000°C occurring at the same time subject all the components of the annular combustion chamber 5 to extremely high load. The annular combustion chamber 5 is therefore provided with an inner lining, not illustrated in any more detail here, which absorbs the thermal load caused by the hot exhaust gas 19. This inner lining includes, for example, combustion chamber bricks which may be provided, in addition, with a corrosion and oxidation protective layer and with a ceramic heat-insulating layer. The first guide-blade row 15 and the mouth region of the gas turbine burner 13 are also subjected to extremely high thermal load. The high thermal load leads to oxidation and corrosion and may also result, for example, in material being stripped off, cracks, deformations, carbonization or flaking. Erosion due to foreign bodies entrained in the exhaust gas is likewise possible.

[00018] The annular combustion chamber 5 must therefore be monitored regularly for such wear phenomena. For this purpose, a remote-controlled inspection device 21 is introduced into the annular combustion chamber 5. The inspection device 21 has a carrying framework 24. The carrying framework 24 is formed by a lower frame 23 and an upper frame 25. Four wheels 29 are mounted in each case both on the lower frame 23 and on the upper frame 25. A translational rail 31 is mounted on the end face of the inspection device 21. A video camera 33, together with a lighting arrangement 35, is mounted on the translational rail so as to be moveable in translational motion from a burner-side end to a turbine-side end of the annular combustion chamber. The video camera 33 and the lighting arrangement 35 are held pivotably in an articulated fork 37. The articulated fork 37 is held rotatably on a shank 39.

[00019] The combination of the translational motion on the translational rail 31 with the rotational motion of the shank 39 and the pivoting motion in the articulated fork 37 allows a complete inspection of the internal walls 9, 11 of the mouth region of the gas turbine burner 13 and of the first guide-blade row 15. A control and supply arrangement 41 disposed on the shank 39 serves for driving the movement for the video camera 33 and the electrical supply of the video camera 33 or the lighting system 35. Furthermore, preamplification of the video signal may take place in the control and supply unit 41. The video signal is conducted out of the annular combustion chamber 5 via a line 43. The power supply for the control and supply arrangement 41 also takes place via the line 43.

[00020] By using the remote-controlled inspection device 21, a complete inspection of the annular combustion chamber 5, without a complicated covering or uncovering of the annular combustion chamber, may be carried out. This results in a considerable reduction in inspection time. Furthermore, storable documentation capable of being understood, irrespective of location, is made possible by the video detection of the state of the combustion chamber. Specialized personnel can thus assess the state of the annular combustion chamber 5 irrespective of the location of the gas turbine 1. Moreover, progress of wear and quantification of the rate of progress of wear are possible by comparison with previous inspections. The remote-controlled inspection device 21 thus provides, as it were, a three-dimensional and time-related mapping of the state of the annular combustion chamber. As compared with a hitherto conventional inspection by direct visual inspection, therefore, there are entirely new possibilities for quantifying the thermally induced wear in the annular combustion chamber 5.

[00021] Fig. 2 shows a top view of an inspection device 21. The inspection device 21 has an electric motor 45. The electric motor 45 drives two of the wheels 29 via a shaft 47. A power supply of the electric motor 45 takes place via a supply line 49. The transmission of video images takes place via the line 43, as in fig. 1, the line 43 being connected to an evaluation arrangement 51. The evaluation arrangement 51 has a monitor 53 on which the video images

can be displayed directly. The evaluation arrangement 51 also has a storage unit 55, via which the video images can be stored. Furthermore, video images of previous inspections can be retrieved by means of the storage arrangement 55. At the same time, a location-synchronized parallel display of current inspection images with previous inspection images can be carried out, so that a change in the state of wear becomes immediately visible. A power supply arrangement 57 serves for the power supply of the electric motor 45.

[00022] Fig. 3 shows a further embodiment of the remote-controlled inspection device 21. The video camera 33 and the lighting system 35 are introduced into the annular combustion chamber 5 via a telescopically extendable rail 61. A manhole 63 serves as access in this case. The rail 61 is C-shaped and can travel around half the circumference of the annular combustion chamber 5. The carrying framework 24 for the video camera 33 and the lighting system 35 is either moved through the annular combustion chamber 5 by means of the rail 61 or the carrying framework 24 is mounted so as to be capable of traveling on the rail 61.

[00023] Fig. 4 shows a further embodiment of the inspection device 21. In this case, the carrying framework 24 for the video camera 33 and the lighting system 35 is moved through the annular combustion chamber by way of an articulated arm 71.

[00024] The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

Patent claims

1. A remote-controlled inspection device (21) for an annular combustion chamber (5) of a gas turbine (1), having a remotely steerable drive mechanism (29, 45, 61, 71), a moveable video camera (33), a lighting arrangement (35), a carrying framework (24) for the video camera (33), for the drive mechanism (29, 45, 61, 71) and for the lighting arrangement (35), and having means for transmitting video images from the video camera (33) to an evaluation arrangement (51).

2. The inspection device (21) as claimed in claim 1, wherein the drive mechanism (29, 45, 61, 71) has an electric motor (45) and wheels (29), at least one of said wheels (29) being capable of being driven by the electric motor (45).

3. The inspection device (21) as claimed in claim 1 or 2, wherein the drive mechanism (29, 45, 61, 71) has an, in particular, C-shaped rail (61), by means of which the carrying framework (24) is capable of traveling.

4. The inspection device (21) as claimed in claim 1, wherein the drive mechanism (29, 45, 61, 71) has an articulated arm (71), on which the carrying framework (24) is mounted.

5. A method for inspecting an annular combustion chamber (5) of a gas turbine (1), wherein a video camera (33) is introduced, by remote steering, into the annular combustion chamber (5) and is pivoted in such a way that video images of regions of the internal walls (9, 11) of the annular combustion chamber (5) are recorded by the video camera (33), said video images being transmitted

to an evaluation arrangement (51) positioned outside the annular combustion chamber (5).

Abstract

Inspection device for an annular combustion chamber of a gas turbine and method for inspecting an annular combustion chamber of a gas turbine

The invention relates to a remote-controlled inspection device (21) for an annular combustion chamber (5) of a gas turbine (1). Inspection takes place by means of a video camera (33). Inspection by means of the inspection device (21) achieves a considerable reduction in the inspection time and an accurate documentation of the wear of the annular combustion chamber (5).

Fig. 1

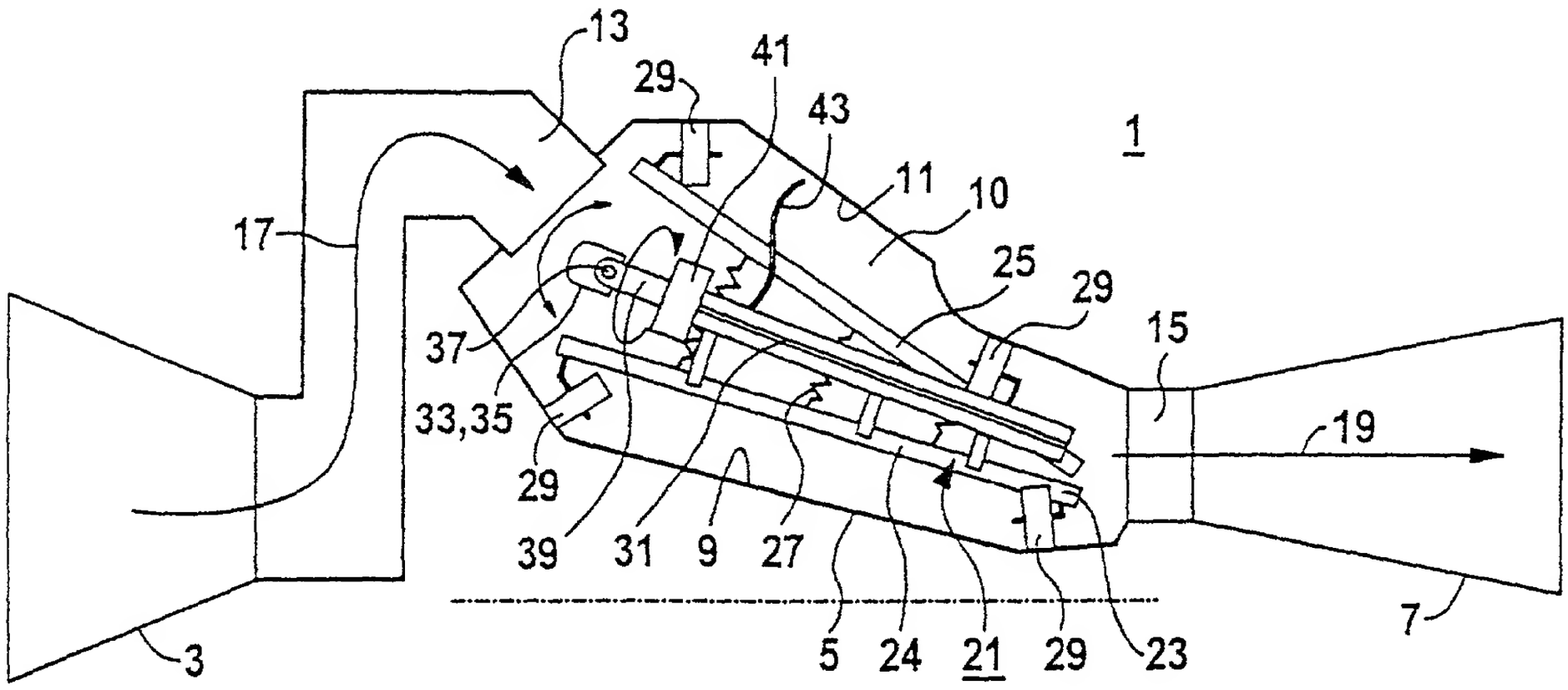
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FIG 1

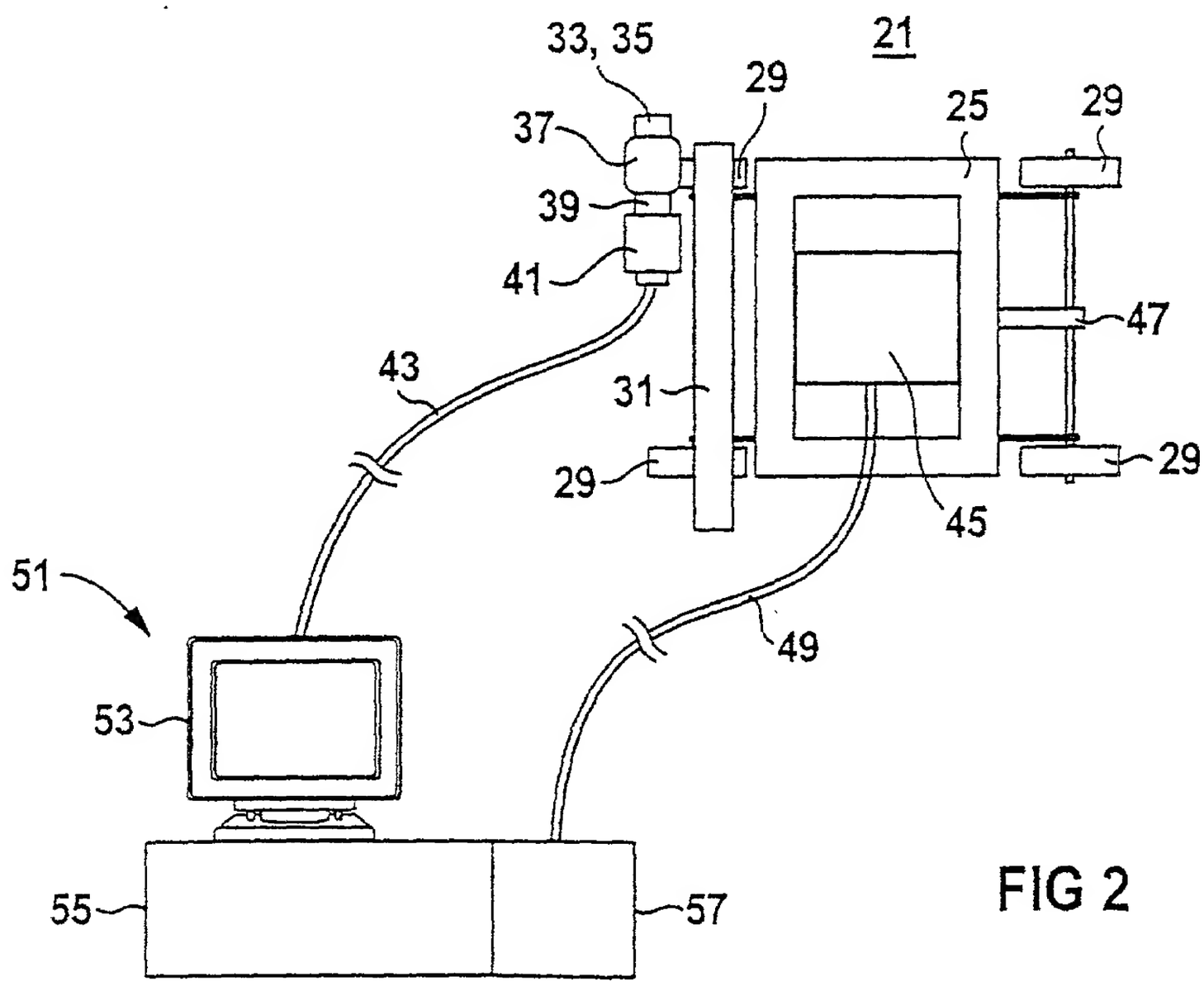
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FIG 2

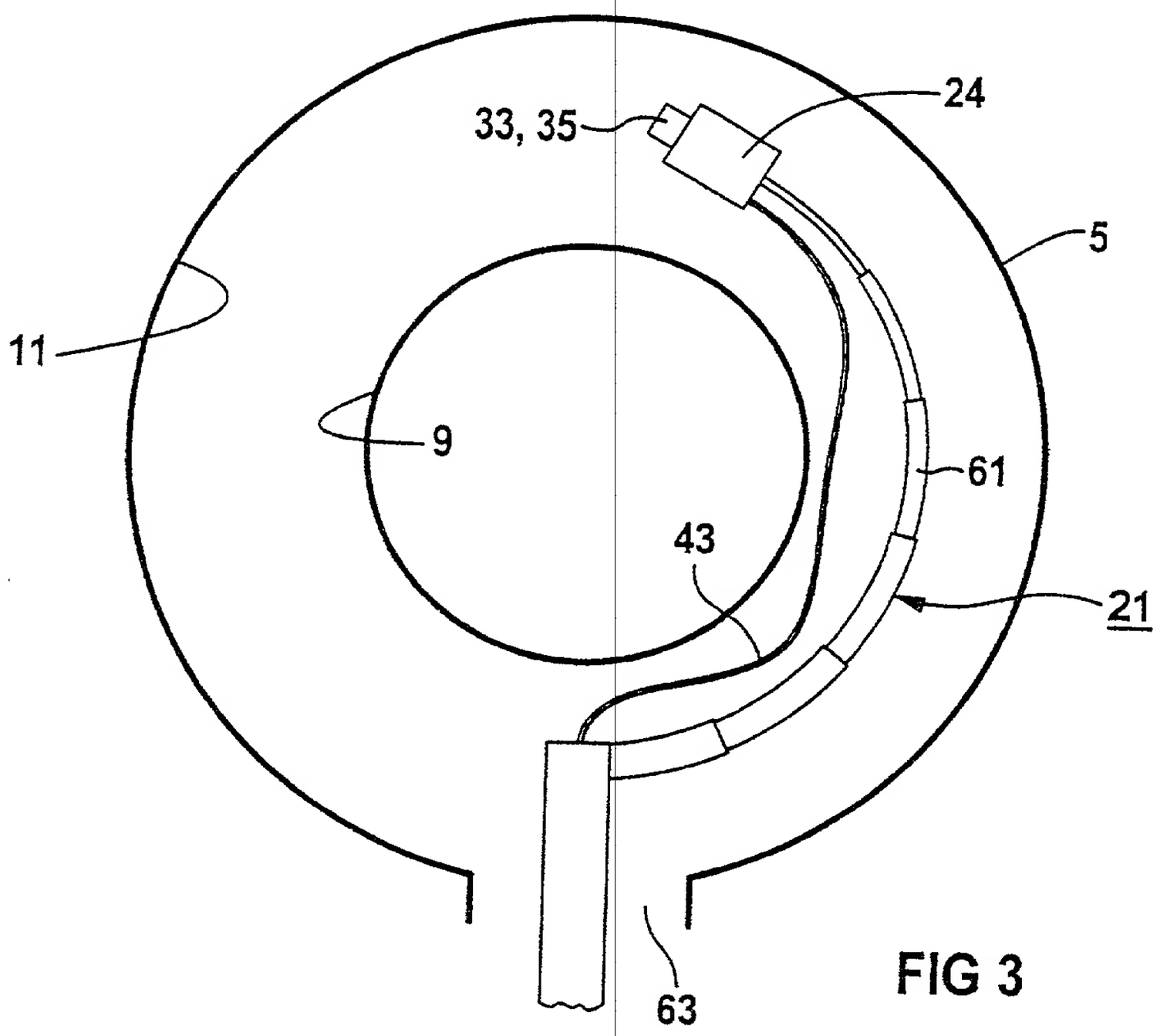

FIG 3

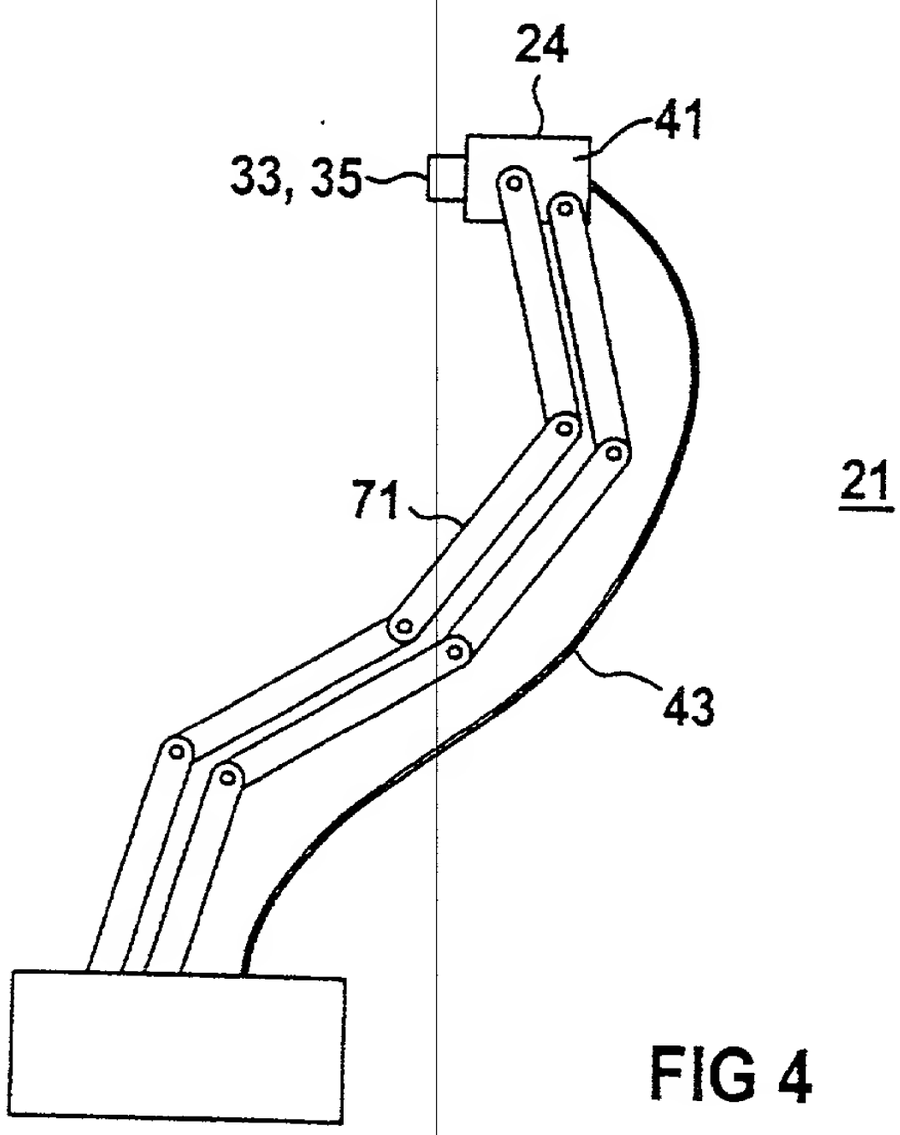

FIG 4

Declaration and Power of Attorney For Patent Application
Erklärung Für Patentanmeldungen Mit Vollmacht
German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

As a below named inventor, I hereby declare that:

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I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Inspektionsvorrichtung fuer eine Ringbrennkammer einer Gasturbine und Verfahren zur Inspektion einer Ringbrennkammer einer Gasturbine

INSPECTION DEVICE FOR AN ANNULAR COMBUSTION CHAMBER OF A GAS TURBINE AND METHOD OF INSPECTING AN ANNULAR COMBUSTION CHAMBER OF A GAS TURBINE

deren Beschreibung

the specification of which

(zutreffendes ankreuzen)
☐ hier beigefügt ist.
☒ am 12.05.2000 als
PCT internationale Anmeldung
PCT Anmeldungsnummer PCT/DE00/01503
eingereicht wurde und am _____
abgeändert wurde (falls tatsächlich abgeändert).

(check one)
☐ is attached hereto.
☒ was filed on 12.05.2000 as
PCT international application
PCT Application No. PCT/DE00/01503
and was amended on _____
(if applicable)

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

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I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

German Language Declaration

Prior foreign appplications
Priorität beansprucht

			Priority Claimed	
19924607.6	DE	28.05.1999	☒	☐
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	Yes Ja	No Nein
			☐	☐
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	Yes Ja	No Nein
			☐	☐
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	Yes Ja	No Nein

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

I hereby claim the benefit under Title 35. United States Code. §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §122, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occured between the filing date of the prior application and the national or PCT international filing date of this application.

PCT/DE00/01503 (Application Serial No.) (Anmeldeseriennummer)	12.05.2000 (Filing Date D, M, Y) (Anmeldedatum T, M, J)	(Status) (patentiert, anhängig, aufgegeben)	(Status) (patented, pending, abandoned)
(Application Serial No) (Anmeldeserier nummer)	(Filing Date D,M,Y) (Anmeldedatum T, M; J)	(Status) (patentiert, anhangig, aufgeben)	(Status) (patented, pending, abandoned)

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Customer No.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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Unterschrift des Erfinders Datum X 26.11.01	Inventor's signature Date
Wohnsitz GEROLZHOFEN,	Residence GEROLZHOFEN,
Staatsangehörigkeit DE	Citizenship DE DEX
Postanschrift BLEICHSTR.11 97447 GEROLZHOFEN	Post Office Addess BLEICHSTR.11 97447 GEROLZHOFEN
Voller Name des zweiten Miterfinders (falls zutreffend):	Full name of second joint inventor, if any:
Unterschrift des Erfinders Datum	Second Inventor's signature Date
Wohnsitz ,	Residence ,
Staatsangehörigkeit	Citizenship
Postanschrift	Post Office Address

(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

(Supply similar information and signature for third and subsequent joint inventors).